UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

PRUNING YOUNG DECIDUOUS FRUIT TREES

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BULLETIN No. 313
OCTOBER, 1919

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY
1919

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PRUNING YOUNG DECIDUOUS FRUIT TREES

By WARREN P. TUFTS

INTRODUCTION

The economic conditions existing in California make it incumbent upon the fruit grower to handle his orchard so that it will come into profitable bearing at an early age. Pruning experiments conducted at the University Farm at Davis show conclusively that it is unnecessary to wait seven or eight years for the first returns. For example, when pruned by the new method, providing soil and climatic conditions are favorable, Japanese plums may be made to bear a crate of fruit to the tree the third season and two crates the fourth; French prunes ten to twenty pounds of green fruit the fourth season; and Bartlett pears a box of fruit to the tree the fifth season. Likewise, with proper pruning, the other deciduous fruits may be brought into bearing correspondingly early. This early fruiting, moreover, is not inconsistent with the best development of the tree. The trees which have borne heavy crops on account of the light pruning they have received are larger and stronger than those trees receiving the heavy pruning which is customary in the various fruit districts of California.

Pruning is commonly accepted as one of the necessary orchard operations. The work is carefully and assiduously carried out by California fruit growers and is one of their most laborious and expensive practices. Quite as many systems or methods of pruning prevail as there are fruit districts in the state. Heretofore actual experimental evidence has not been adequate to enable the grower to determine the relative merits of the different methods and to choose with certainty the best practice.

Many pruning experiments covering long periods of years have from time to time been performed in different parts of the United States and other countries. The results of these experiments, however, may not be directly applicable to California orchards. Furthermore, practically all published accounts of carefully conducted pruning investigations deal only with the apple. This fruit, although of great commercial importance, comprises a comparatively small portion of the total acreage devoted to deciduous fruits in California. Finally, little knowledge based on exact experiments exists as to the proper pruning methods for such fruits as the almond, apricot, peach, and

prune. It was deemed advisable, therefore, to repeat many of these pruning tests.

The Pomology Division of the University of California has in progress pruning experiments with almonds, apples, apricots, cherries, peaches, pears, plums, prunes, and walnuts. Obviously, it will take several years to conclude these investigations. The results already obtained, however, throw much light upon the best methods of shaping young trees in order to bring them into earlier fruiting and to secure larger and stockier trees in a more economical way.

WHAT IS PRUNING

Pruning is the art of modifying the natural habit of the fruit tree in order to secure fruit in greater abundance, more regularly, and of better quality than could otherwise be the case. The cutting of a tree is designed to change its form, its function, or both form and function. However, the physiological response of a tree to any kind of pruning is such that it is practically impossible to modify its shape without at the same time profoundly influencing its functions.

Briefly stated, the purposes of pruning are five-fold:

1. To produce a vigorous, mechanically strong, healthy tree, free from sunburn, capable of producing heavy crops over a long period of years.
2. To secure a tree well shaped for convenience and economy in orchard management.
3. To distribute the fruiting area well over the tree.
4. To insure a succession of profitable crops.
5. To secure size and quality of fruit.

PURPOSES OF PRUNING YOUNG TREES

*Promotion of Vegetative Growth.**—At the end of any growing season the root and top development of a tree tend to reach such a balance that the root system is extensive enough to supply the top with adequate moisture and mineral salts from the soil, and the above-ground parts are sufficient to manufacture the complicated plant foods which are necessary for the further growth of the whole plant. When a young tree is dug from the nursery, with consequent loss of roots, this balance is materially disturbed. If the top is not cut back at the

* A recent contribution by Kraus and Kraybill (Bull. 149, Ore. Agric. Exp. Sta.) has shed much light upon certain phases of the pruning question as well as other vexed horticultural problems.

time of planting in the orchard, too many buds will be left to grow, and the reduced root area is unable to supply them with adequate moisture and mineral matter from the soil.

This condition of unbalance will cause the tree to die or to make but a feeble start. If, however, at time of planting the top is cut back, each of the remaining buds will have a larger proportionate share of the available moisture and mineral plant food materials, and the subsequent growth will be more vigorous. Chittenden[4] has shown by careful experiments covering this point that poor growth invariably follows a failure to prune back at planting. In the case of apples on Paradise stock, the set-back from non-pruning at time of planting was noticeable in the three succeeding seasons.

Investigators working with various horticultural plants have, from time to time, used circumference of trunk, length of new shoot growth, height and spread of branches, size and weight of leaves, as proper indices of the vegetative vigor of the plant. Probably the weight of the entire plant top and root is the most accurate index of the growth, taking into consideration not only top but also root elongations, and likewise increments to the older portions of both top and root. Obviously it is impossible to take up a tree at stated intervals, wash the soil from its roots, weigh, and then expect that plant, when replaced, to continue its development undisturbed. It would seem from the measurements herein recorded that a definite correlation exists between trunk circumference and the weight of both root and top. Such being the case, a simple measurement of the circumference of the trunk of the tree is a fair indication of its total development.

With the weighing and measuring of trunk circumferences just above the crown of the tree of 241 two-year-old black walnut (*Juglans California* var. *hindsii*) seedlings, 245 almond (*Prunus communis*) seedlings, and 215 peach (*Prunus Persica*) seedlings, the author has been able to calculate the correlation existing between root and top development as well as the correlation existing between trunk circumference and root and top weights. These seedlings received ordinary commercial nursery treatment, but instead of being budded during the latter part of the first summer and then severely cut back during the dormant season, they were allowed to make two seasons' undisturbed growth in the nursery row. At the end of two years the entire planting was removed. The walnuts were pulled with a tractor soon after a heavy rain, with the result that practically the whole root system was obtained. Walnut trees with broken tops or roots were not included in these measurements.

It was found impracticable to pull the fibrous-rooted trees with a tractor; consequently as complete a root system of the peach and almond was not obtained as with the walnut. It is thought, nevertheless, that inasmuch as the root systems removed with these trees were as uniform as possible with hand digging, the measurements and weights are decidedly worth while.

TABLE 1

SUMMARY* OF CORRELATION COEFFICIENTS CALCULATED FOR TWO-YEAR-OLD SEEDLING TREES

Tap Rooted Plant	
Walnut	
Correlation between weight of root and top	.83 ± .010
Correlation between circumference of trunk and weight of top	.83 ± .013
Correlation between circumference of trunk and weight of root	.83 ± .013
Fibrous Rooted Plants	
Almond	
Correlation between weight of root and top	.46 ± .034
Correlation between circumference of trunk and weight of top	.91 ± .0074
Correlation between circumference of trunk and weight of root	.76 ± .018
Peach	
Correlation between weight of root and top	.89 ± .0095
Correlation between circumference of trunk and weight of top	.92 ± .007
Correlation between circumference of trunk and weight of root	.84 ± .013

The coefficients just given are high, and are indicative of a very close degree of correlation existing between the circumference and weight of the tree, both top and root. With this fact established, it would seem that reliance may be placed on the results obtained from any orchard treatment influencing the growth of non-bearing trees when such results are based on trunk circumference measurements. Attention is here directed to the fact that this form of measurement takes into consideration only quantitative changes in the plant, and pays no regard whatever to qualitative changes. For this reason, circumference measurements lose much of their value as soon as the trees cease their purely vegetative growth and prepare for the production of blossoms and fruit.

Experiments devised to answer the question as to the results to be expected from light and heavy pruning of young trees have been conducted at the University Farm at Davis during the past four years. These investigations have in large part been preliminary to a more thoroughly detailed study of the whole pruning problem as it relates to California pomology. The results have been so striking,

* For detailed discussion, see article by author *in* Monthly Bull. Calif. Dept. Agri., Vol. VIII, No. 9, Sept., 1919.

however, and so much at variance with common practices in the state that it is thought best to publish them at this time. In most instances the number of trees involved in this study has been adequate to allow of definite conclusions being drawn. In a few instances the number of trees receiving identical treatments was relatively small. The results, however, have in no instance been contradictory.

The fruits under experiment were the apricot, cherry (sweet), peach, pear, plum (Japanese and European), and prune. These trees were planted in February, 1915, on deep soils of the Yolo series running from fine sandy loam to clay loam, and have received only one irrigation, and that inadequate, during one of the four seasons they have been in the orchard, and, with the exception of the pruning treatment, have received identical culture. The following table briefly summarizes the results of the different pruning treatments after one summer's growth. Measurements were taken at the beginning and at the end of the third season.

TABLE 2

AVERAGE INCREASE IN CIRCUMFERENCE IN CENTIMETERS

Kind of fruit	Pruned severely. Thinned and headed severely.	Pruned moderately. Thinned and headed moderately.	Pruned lightly. Thinned only.
Apricot (Royal)	11.7 cm.	12.6 cm.	15.3 cm.
Cherry (Napoleon)	10.0	11.2	12.3
Peach (Elberta)	12.0	16.9	19.4
Pear (Bartlett)	8.7	9.1	9.7
Plum (Japanese—Climax)	6.3	10.4	11.3
Plum (European—Pond)	7.2	8.8	9.4
Prune (French)	6.2	7.1	8.4
Average	8.9	10.9	12.3

Comparable results have also been obtained with almond trees planted in February, 1917.

In this connection it is interesting to note the results of similar experiments conducted with the apple under an entirely different environment. (The apple was not included in the plantation in which the experiments above recorded were conducted, not being considered a commercially important fruit in the hot interior valleys of California). Bedford and Pickering,[2] at Woburn, England, have for many years conducted pruning experiments with apples. The results of these investigations show that the less a tree is pruned the larger and heavier it becomes. At the end of twelve years trees which had been

heavily pruned, lightly pruned, and others which had received no pruning were dug up and examined. It was found that those trees which had been heavily pruned during the experiment were 16 per cent lighter than those which had received a light pruning only, and the trees which had not been pruned at all were 20 per cent heavier than the lightly pruned ones. Alderman and Auchter,[1] in experiments carried on for four years in West Virginia, found that heavily pruned trees had an average increased trunk diameter of 1.61 inches, those moderately pruned one of 1.69 inches, and those lightly pruned one of 1.93 inches. Likewise, Gardner[5] in Oregon found that, on the average, the unpruned tree increases in size a little more rapidly than the tree that is winter-pruned only, or that is both winter- and summer-pruned. Attention should be directed at this point to the fact that in all these cases cited, measurements were made on young trees where the bulk, if not all, of the plant's energy was being expended upon wood growth, and little upon fruit production.

A word of explanation of the facts just presented may not be amiss. Fruit growers have for many years been aware that the buds toward the tip of the shoot are the ones most likely to put out new shoot growth at the first opportunity. A large per cent of the total plant food stored in twigs is in the uppermost parts. Magness[9] has shown by defoliation experiments that plant food synthesized in one portion of the tree is transported only to a limited extent for the nutrition of other parts of the same tree. He also points out that the larger the foliage area is the better will be the nutrition of adjacent parts. It is a common observation that leaves are larger and more abundant near the tip of the shoot. Likewise Chandler[3] in his studies with sap concentration (which may be taken as an index of plant food storage) found higher concentrations in the upper twigs and leaves than in corresponding parts lower down. Observations taken during the dormant season, although closely following those just noted, in some instances showed a greater concentration of sap in the trunks than in the twigs.

Bearing these facts in mind, it is easy to account for the greater total growth of long-pruned shoots than of adjacent shoots pruned short, and of long-pruned trees than of trees severely headed-back. We find here also an explanation of the greater formation of fruiting wood on trees "thinned-out" as compared with trees "headed-back" (see page 124). In this connection, the fact must be remembered that any pruning reduces, in direct ratio to its severity, not only stored food materials but also the potential leaf area of the plant which

constitutes the principal "machinery" for the manufacture of carbohydrates (a most important group of plant foods) and the building up of the more complex plant foods from materials taken from the soil by the roots.

Heavy dormant pruning undoubtedly has the tendency to restrict optimum root development. The roots are incapable of carbohydrate synthesis and are dependent upon the leaves and the above-ground parts for their supply. If such supply is limited by top pruning, then, as an absolute consequence, the root system must be limited. In the experiments already noted, the writer has defintely shown that a very close correlation exists between parts above and those below ground. A large top presupposes a large root system, and any treatment which limits root development indirectly, but surely, tends to limit the growth of stem and branches, since the water and mineral intake are quite as important factors in growth, development and fruiting as are the substances built up or found in the tops themselves.

Formation of the Framework.—Plants do not increase in height except through the growth of buds and the elongation of the terminal growing point. The height of the main trunk is determined when the tree is cut back at time of planting. The term "height of head" will in this article have reference to the distance existing between the ground and the lowest scaffold limb. Sufficient trunk space should be left so that at least six, or better eight inches will intervene between the main scaffold branches. This would mean that if the young tree is arbitrarily cut off at twenty-four inches from the ground and three main branches selected, the lowest one should stand from eight to twelve inches from the ground. Personal preference will determine the number of main scaffold limbs, but care should be taken not to have too many. The author's preference is for three. With only two main branches, there is danger of splitting. Four or five main limbs make it necessary to cut the tree rather high at planting time or else take several years to develop the scaffold branches. At five feet from the ground, five to seven main branches are all that can usually be accommodated without crowding. The pruner should have in mind at all times his ideal tree as it will appear at bearing age, and shape his pruning accordingly.

The three main branches selected should be properly balanced around the trunk and form equal angles of about 120 degrees each (fig. 1). Likewise, these same branches should be spaced up and down the trunk as above directed (fig. 2). These primary scaffolds should be headed at from fifteen to thirty inches or more from their juncture

with the trunk. The severity of this first heading is dependent upon the total length of new wood, its angle of growth, and the formation of lateral branches on current season's wood (as in the case of the peach). It may be somewhat misleading to make general statements, but it is necessary here to give some idea as to the amount of heading back the young tree should receive at the first dormant pruning. The greater the amount of one year growth, the longer the branch should be cut; care should be taken, however, to see that the secondary branching does not come too high. The more horizontal the growth, the more severe will be the necessary heading-back in order to secure ease of cultivation. Trees forming branches on current season's growth may

Fig. 1.—Looking downward on a young tree, showing a satisfactory arrangement of scaffold branches around the trunk. This will give balance and symmetry to the tree.

be headed more lightly than otherwise because such heading, coming as it does above the forks formed naturally during the growing season, is not designed to secure additional branching, but rather to form proper angle and spread.

The common advice has been to head back these selected shoots severely in order to secure (1) branching, and (2) stockiness. As usually practiced this advice defeats its avowed purposes. If the shoots are headed to six or eight inches and then an attempt is made at the second pruning to secure two branches from each of the three main shoots, crowding is sure to take place, and the result is that in nearly all cases only one growth is ultimately secured from each of the primary scaffold branches.

The primary scaffolds headed lightly, as above indicated, at the end of the first growing season will allow sufficient room for the secondary main branches to develop the second summer. With such fruits as the almond, apricot, peach, and Japanese plum no further heading is desirable (if sufficient branching and spread have been obtained with the one light heading) until the tree comes into full bearing, at which time active vegetative growth is naturally retarded. Under certain conditions, cherries, pears, and similar fruits require one or more additional headings (either winter or summer) to form the necessary framework and to secure the desired spread. Varietal characteristics largely determine whether or not lateral branches will be formed by using only a thinning-out system of pruning. The Bartlett pear, for example, under certain environments throws laterals without heading the new growth, but the Lincoln pear must be headed to force laterals.

Fig. 2.—Spacing of branches up and down the trunk must be sufficient to secure mechanical strength and to avoid weak, debris-catching crotches. Compare fig. 15.

It has already been pointed out in detail that heavy pruning will subdue and light pruning will encourage total growth in young trees. This rule will find ready application in the maintenance of the proper balance between various parts of the young tree. The upper shoots will generally have a tendency to make a stronger growth than the lower branches and must accordingly be cut more heavily. To encourage any branch or portion of a tree, therefore, it is essential to prune such parts relatively lightly in comparison with the branches or parts with which it must compete.

In this same connection, attention must be called to the evil results of even cutting (fig. 3). If two shoots forking from the same branch are headed evenly, the chances are that they will develop equally, with a resultant sharp-angled crotch which is usually mechanically weak.

On the other hand, if the shoot which best continues the general direction of the framework of the tree is cut longer it will grow strong. The second shoot will, as a consequence of being cut shorter, develop into a minor fruiting branch with a strong, broad-angled crotch (fig. 4).

The relative stockiness of branches of trees headed severely as opposed to those headed lightly is quite well shown by the following measurements:

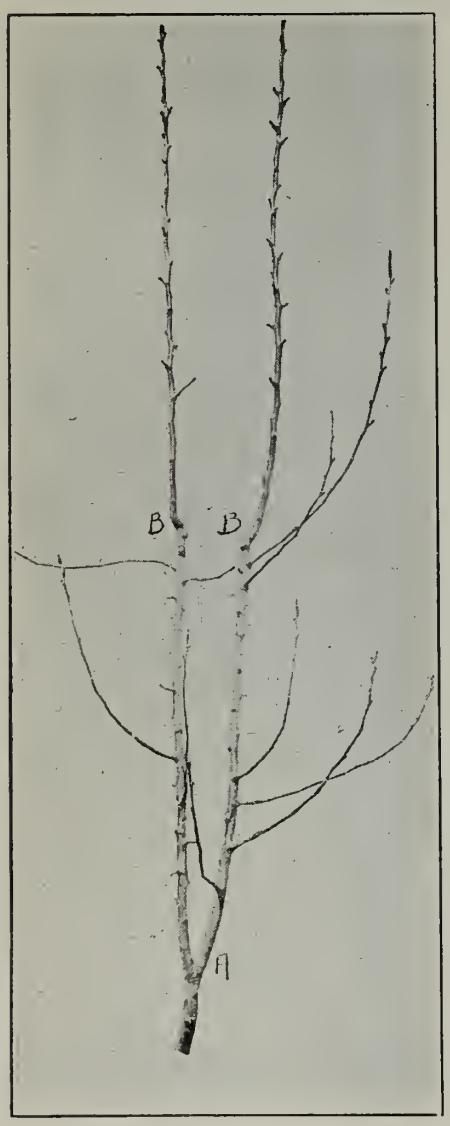

Fig. 3.—Equal development of branches and resulting sharp-angled, weak crotch (at A) occasioned by even cutting at B.

A plot of apricot trees was headed evenly at the time of planting and again at the end of their first season's growth. At the end of the second season one-third of these trees were given a heavy pruning, one-third a moderate pruning, and the remainder a light pruning by thinning only. At the end of the third season girth measurements were made of all main branches at a height of three feet from the ground. Those trees which had been severely pruned had an average girth of main branches of 3.85 centimeters, those moderately pruned of 4.66 centimeters, and those lightly pruned a girth of 5.09 centimeters. The measurements were in all cases on limbs of the same age. These results are in accord with experiments carried out in Germany,[6] England,[2] West Virginia,[1] and Oregon.[5] Inasmuch as all these experiments conducted under such widely varying conditions yielded practically the same results, no further confidence should be placed in the tradition that it is necessary to cut severely in order to secure "stockiness." It would seem that if mechanical strength, whether to uphold heavy crops or to resist the pressure of high winds, is wanted, this is to be obtained most easily by the lightest cutting compatible with good form and branching, which probably must be determined in many instances by individual trial.

Regulation of Time of First Fruiting.—Light pruning to obtain larger and stronger trees goes hand in hand with early fruiting. On

the contrary, the production of luxuriant vegetative shoot growth induced by heavy cutting of the young tree, is antagonistic to the bearing of fruit. This presents the question as to the influence of early fruiting upon the productive life of the orchard.

When a deciduous fruit tree has a spread of, say, five feet, it can with all safety be allowed to fruit, no matter what its age. The rule

Fig. 4.—Unequal development of branches and mechanically strong crotch caused by uneven pruning at points A and B. Both branches are of the same age, but are unequally developed because of uneven cutting.

for the fruiting of a young tree is the same as that governing the digging of new potatoes—"when they are big enough, they're old enough."

Many growers definitely adopt a scheme of pruning designed to keep their trees from fruiting for eight or ten years, and then when the time comes for the orchard to produce profitable crops it quite often refuses to respond. This behavior results from different causes. In many instances, with such fruits as the apple, pear, prune, and

cherry, no fruit wood has been allowed to develop, every spur having been removed at the annual pruning, and to expect fruit from orchards where no attempt has been made to develop a fruit-spur system is the same as expecting a factory without machinery to turn out a finished product.

With the possible exception of the peach and the quince, the fruit-spur system is the machinery necessary to the production of profitable deciduous tree-fruit crops. The promotion of the new shoot growth by severe cutting likewise prevents the formation of fruit buds. Certain buds are potentially fruit buds, only needing for their development sufficient nourishment. If, however, the equilibrium which exists under normal conditions between root and top is constantly disturbed, all the strength of the tree is utilized in reëstablishing this balance, resulting in the non-formation of fruit wood. Heavy cutting opposes fruit production because, as a result, plant food is used up in the production of new shoots instead of in the formation of fruit buds. This luxuriant growth, in turn, by its very denseness robs of air and sunlight any wood attempting to form fruit buds for the following year. This fact is illustrated in figure 5, which shows a French prune that, at the end of the second summer, was pruned by heading-back, and figure 6 a similar tree which was merely thinned-out. The former tree shows excessive vegetative growth of new branches above, but lack of fruit-spur development below; the latter shows adequate vegetative growth throughout and a fine development of fruit spurs. The tree shown in figure 6 bore a good crop of fruit during its fourth season in the orchard. The tree in figure 5 cannot possibly produce until its fifth season, and then it will take several years for its production to catch up with the other tree. All this was brought about by the wrong pruning during only one season. Each severe heading-back puts off profitable production, not only one year but in many cases for several years. The more years severe pruning is given, the more disastrous will be the results.

The terms "heading-back" and "thinning-out" perhaps need additional explanation. If the new wood of a tree were given a 50 per cent heading-back, it would mean that the terminal half of the past season's growth had been removed (fig. 7*b*). A 50 per cent thinning-out would mean that half the total number of year-old shoots had been removed entirely, the remaining half in no way being cut (fig. 7*a*). The terms "heading-back" and "thinning-out" are not necessarily confined to the cutting of one year wood. Any pruning

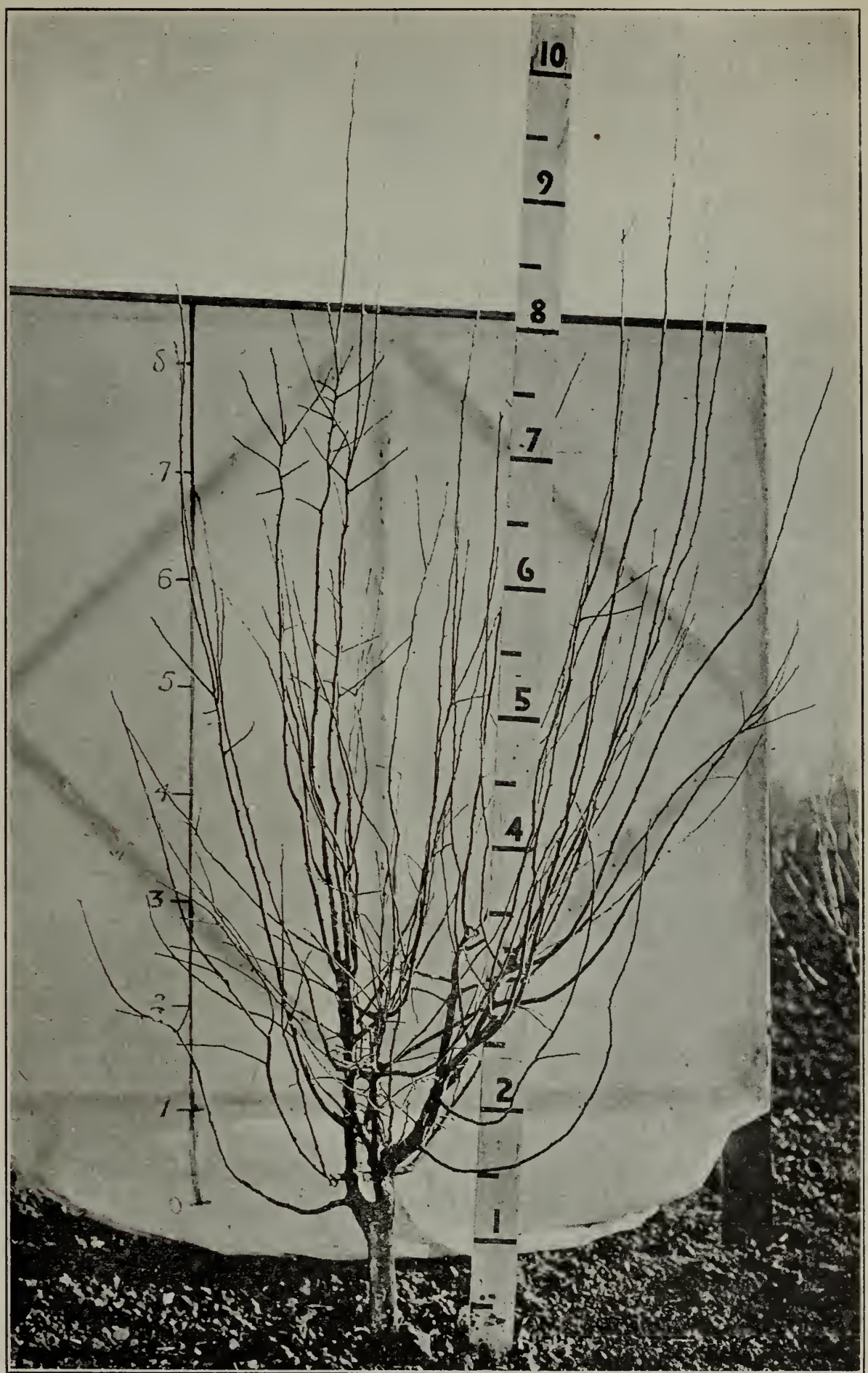

Fig. 5.—Exuberant wood growth on a three-year-old French prune. This tree was cut back severely at the end of the first and second seasons.

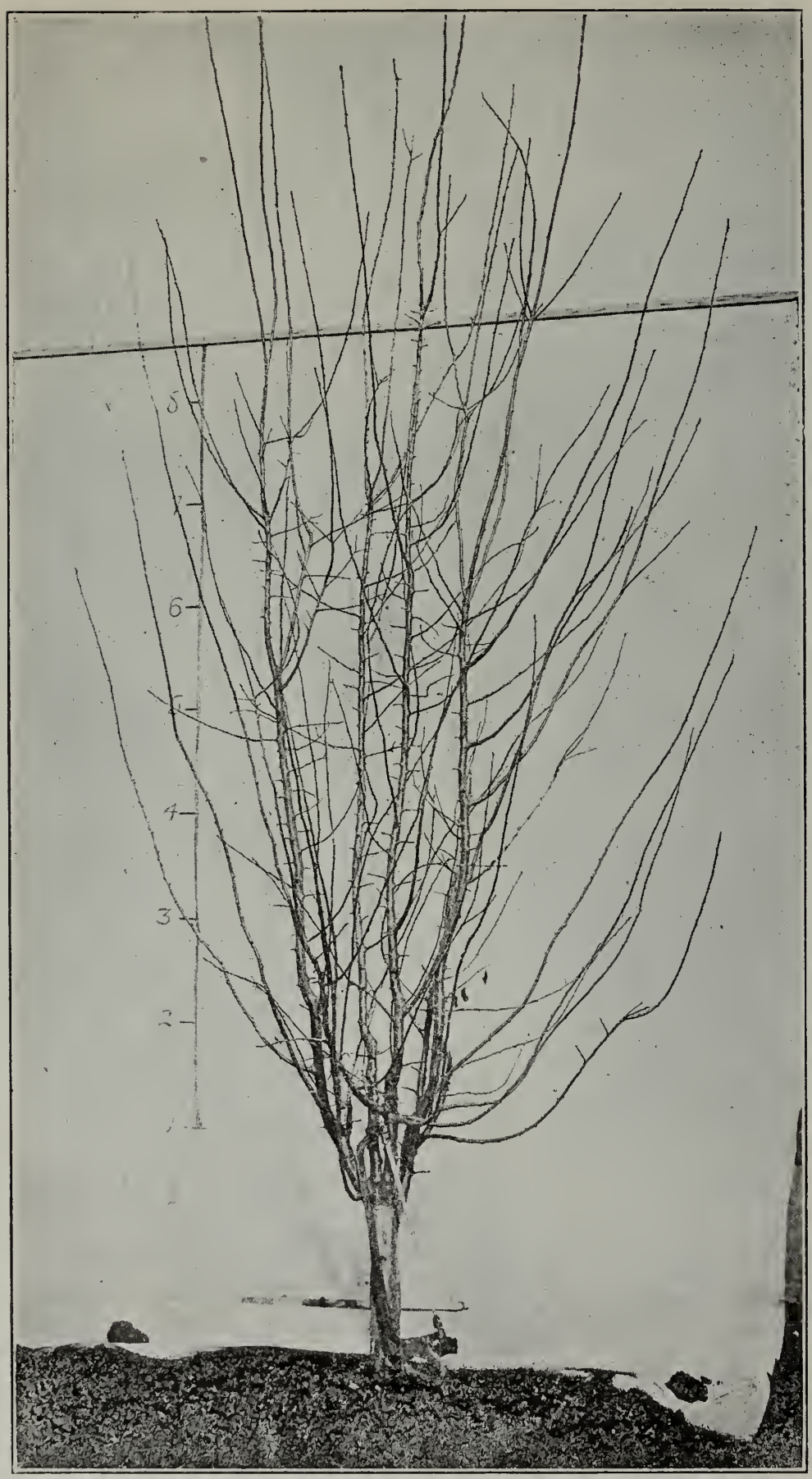

Fig. 6.—An ideal development of fruit spurs and lateral wood growth on a three-year-old French prune. Good wood growth was made with no heading. Note the poor main crotch caused by selection of branches arising from one point on the trunk.

which leaves a stub, no matter how old the wood, may be considered heading. In thinning-out, either an entire branch is removed, or else the cut is made to a lateral.

A simple mathematical calculation shows that in the formation of a fruit-spur system a thinning-out process is superior to heading-back. The primary object of heading is to produce a certain amount of new vegetative growth. For the sake of clearness, we will suppose that a given tree has two new shoots each bearing ten vegetative buds.

Fig. 7.—What is meant by the expressions "thinning-out," "heading-back," etc.: *a*, an apple branch with one-year shoots "thinned-out" 50 per cent; *b*, an apple branch with one-year shoots "headed-back" 50 per cent; *c*, an apple branch with one-year shoots "thinned-out" by two-thirds; *d*, an apple branch with one-year shoots "headed-back" by two-thirds.

The problem is proposed as to which system of pruning will give the greatest number of spurs, a 50 per cent heading-back, or a 50 per cent thinning-out? In each case ten buds remain after pruning; in the former treatment these are divided five on each of the shoots, in the latter all are on one shoot. In the case of the heading-back, the chances are that at least five of the total ten buds on the two growths will throw out new shoots, with a possibility of three other buds develop-

ing fruit-spurs, the last two buds remaining dormant. If, on the other hand a thinning-out is given and all ten buds remaining are on one shoot, although varietal characteristics here play an important role, the probability is that these will be divided somewhat as follows: new shoots two, spurs five, dormant buds three. In our pruning experience this hypothetical case is illustrated in each essential part in every kind of tree producing a spur system. The need is readily seen of having clearly in mind the results aimed at by any pruning system. Figure 8 shows the influence of heading and non-heading upon the formation of fruit spurs.

EFFECT OF SUMMER–PRUNING YOUNG TREES

In the abundant literature dealing with the various phases of pruning, many references are made to "summer-pruning." This practice has in nearly all instances been employed with the end in view of increasing fruitfulness in full-bearing trees. Considered from such an angle, the discussion of the adaptability of summer-pruning to California conditions is not pertinent to this article. The utilization of summer cutting in the training of the young non-bearing tree must, however, be considered, both on account of its importance and of the extent to which it has been practiced during recent years.

Pruning may profitably begin the first summer the trees are in the orchard. As soon as the young tender shoots are three or four inches long, the trees should be carefully examined and any growths not to be utilized in building the main framework of the tree pinched back. If done at this time, all of the strength of the plant will go toward a heavy vigorous growth in the remaining branches, which are to be permanent. Quite often, by the suppression of shoots undesirably placed, by merely pinching off the tips, growth can be induced where wanted. It is a good plan to go over the orchard about a month or six weeks after this first thinning in order to see that no new, vigorous, undesirable shoots have arisen. In the suppression of the undesirably placed growths, two or three leaves should be left next to the trunk in order to shade it and thus prevent sunburn. Evaporation from the surface of these leaves cools the adjacent parts, thus opposing scald and drying out. (See page 139.) The question is sometimes raised as to the advisability of heading-back the three main branches during the first summer. The best results have been secured by allowing them to make an undisturbed growth.

During the second and succeeding summers and until exuberant wood growth is slowed down by fruiting, it is often desirable to give

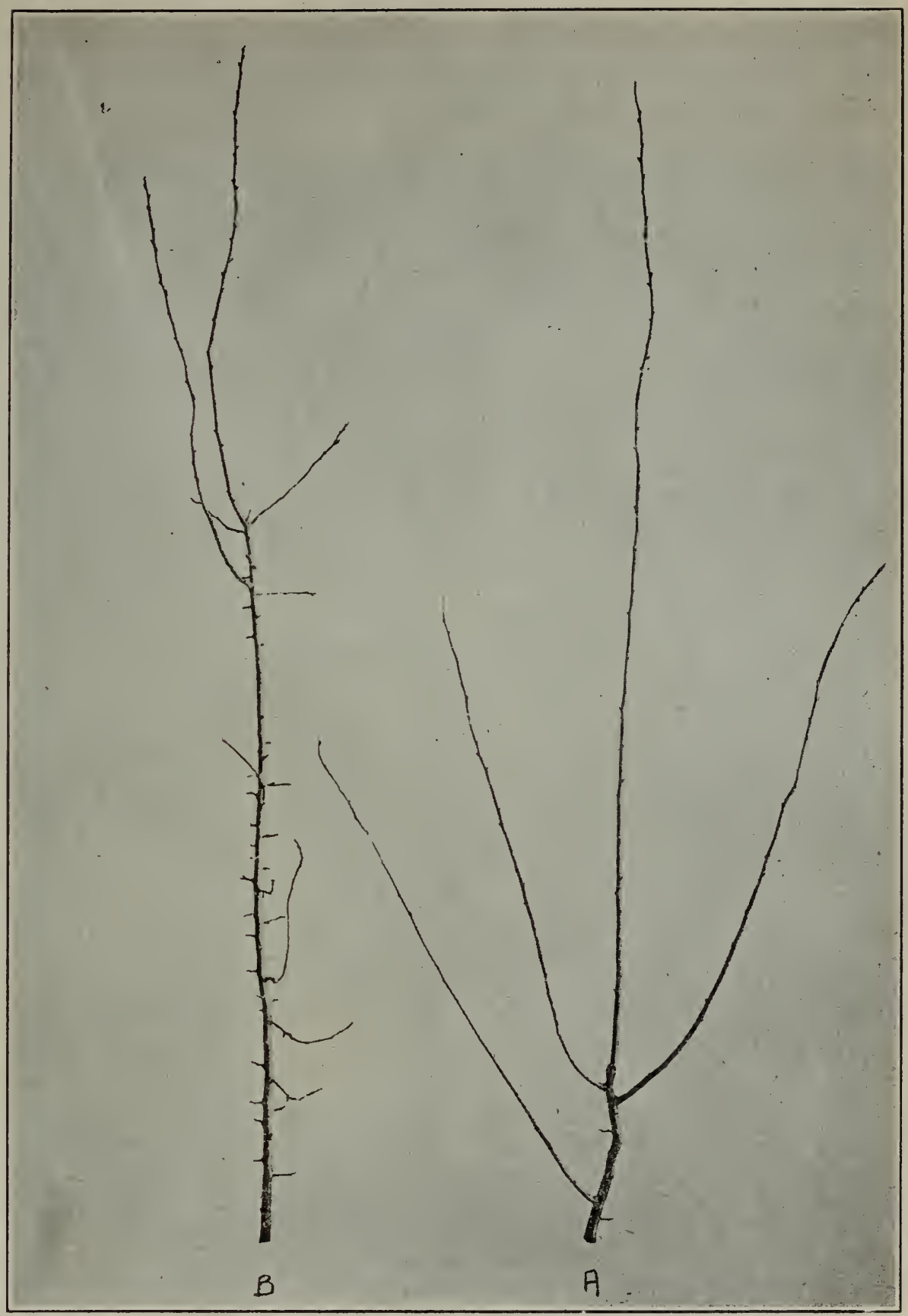

Fig. 8.—*a*, A two-year-old prune branch which received a heading-back at the end of previous season. Note production of shoots and lack of fruit-spurs. *b*, A two-year-old prune branch which was not headed-back at end of previous season. Note production of fruit-spurs, together with sufficient amount of new wood.

the vigorously growing trees a pruning during the *early* part of the season in order to direct all the energies of the tree into those branches which will be retained as the future framework. If the trees are favorably located and make a vigorous start the second summer, the

Fig. 9.—A Nonpareil almond tree at the end of the second growing season. This tree, in addition to having been thinned-out and lightly headed-back at the end of the first season, received a further thinning-out and heading-back during the following May. Note the large numbers of fruit-spurs formed on both one and two-year-old wood.

new shoots usually attain by the middle of May a length equal to or exceeding that which should be left at the second dormant pruning. With the long growing seasons which are experienced in nearly all

the deciduous fruit growing sections of California, the dormant pruning usually performed during the second winter may be moved up to the preceding May, with the purpose in mind of obtaining the ordinary second and third seasons' shaping during the second year

Fig. 10.—The same Nonpareil almond tree as in fig. 9 after having been pruned. Note that all the main branches are formed and that no further heading-back is necessary. This tree should produce a good crop during its fourth season in the orchard.

of the orchard's life. Pruning done at this time not only hastens the training of the tree, but also allows the removal of many unnecessary

shoots, thus reducing to the minimum the second dormant pruning, with consequent advantages as already mentioned (page 117). The weight of brush actually removed from prune trees at the second dormant pruning was, on the average, in the case of trees receiving the summer-pruning, 0.4 pounds per tree, and where no summer-pruning had been practiced, 1.3 pounds per tree.

A most important feature of the summer-pruning just outlined is its influence on the formation of fruiting wood. Figure 9 shows a Nonpareil almond tree at the end of the second growing season. This tree, in addition to having been thinned and lightly headed-back at the end of the first season, received a further thinning and heading during the following May. Note the large number of fruit spurs formed on both one- and two-year-old wood. Figure 10 shows the same tree after pruning. No further heading-back is necessary, as all the main branches are already formed. An almond orchard pruned according to this system should produce a few nuts the third season and a fair commercial crop the fourth season.

Judgment must be exercised as to the adoption of this system of summer-pruning. Trees must be grown under favorable soil and moisture conditions. If the pruning is done early in the season and other conditions are as outlined, the author can see no reason why an orchard under such a pruning treatment cannot be brought into profitable bearing a year to three years sooner than is now the general custom. Whether this early summer training should be continued during the third and fourth summers depends upon the exuberance of growth and the formation of fruit wood. If the trees show no indication of settling down to fruiting, and the vegetative growth is so dense that fruit spurs on the lower portions of the tree are shaded, then summer-pruning, especially a thinning process, may be advisable during later years. Likewise, if sufficient branching has not been obtained, this early summer pruning may be employed for several seasons, being of special value in securing "spread" with obstinate upright-growing trees, like the sweet cherry.

Summer-pruning, whether performed early or late in the season, exerts a marked influence on vigor as measured by trunk increments. During the summer of 1916 the writer subjected four blocks of flourishing two-year-old trees consisting of apricots, cherries, peaches, pears, plums (Japanese and European), and prunes, to various treatments. Block A received no summer-pruning, and the average increase of the trunks was 7.5 centimeters (152 trees). Block B received a moderate thinning-out and heading-back on May 4, and

the average increase of the trunks was 6.5 centimeters (252 trees). Block C received a moderate thinning-out and heading-back on May 4 and again on July 11, and the average increase of the trunks was 5.2 centimeters (96 trees). Block D received a moderate thinning-out and heading-back on August 8, and the average increase in diameter of the trunks was 5.4 centimeters (30 trees. Only apricots, cherries, and pears in this block.)

From the figures just presented it would seem that summer-pruning at any time is devitalizing, and that mid-summer cutting is more weakening than that done during the early part of the season. It is to be further noted that two comparatively early summer-prunings were only a little more weakening than one given late in the growing period.

A moment's consideration of one or two facts of plant growth will make clear the results obtained in these summer-pruning experiments. As previously stated, early summer growth is made at the expense of stored food material, and to remove a certain portion of the foliage before these new leaves have had an opportunity in turn to manufacture and store plant food, robs the plant to the same extent. After active shoot elongation ceases, the plant turns its energies to the manufacture and storage of plant food for the succeeding year. The later a pruning is given in the growing period during which active shoot elongation is taking place with no corresponding storage of plant food, the greater will be the plant's loss, provided such pruning is proportionately heavy; a 50 per cent pruning early in the season removes less than a 50 per cent pruning late in the season. If the cutting during the latter part of the summer is designed to give the same relative shape as results from a pruning given during the early part of the season, more wood must be removed both by thinning and heading, especially if the new branches are to be secured at approximately the same height from the ground. Under the arid conditions existing in many orchard sections of California, the soil moisture may be insufficient to force a vigorous new wood growth late in the season, even if such growth could be properly matured before the frosts of early winter. The orchardist practicing late summer-pruning on young trees may lose in a two-fold manner:

1. The leaf area of his trees is reduced just as the time of beginning of maximum storage of plant food in fruiting and vegetative parts; and

2. As no benefits may accrue from late summer-pruning, he loses the cost of the pruning, which is expensive, coming, as it does, during the fruit harvesting season when labor is scarce.

In spite of the reduction in vigor just noted, results from practical applications of an *early* summer-pruning seem to thoroughly justify the practice, providing the trees are in a thrifty growing condition and that the work is done as early as possible in the growing season;

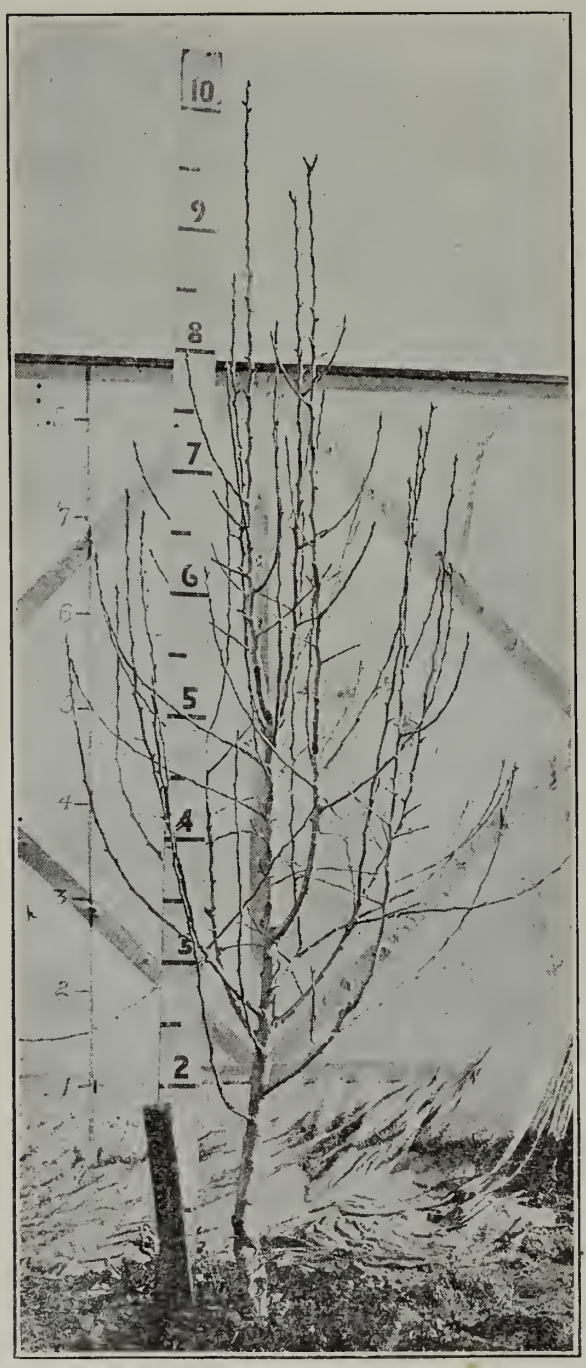

Fig. 11.—A pear tree trained as a leader or pyramid type of tree.

in all valley locations not later than the first week in June, and preferably by the middle of May. Under foothill conditions, these dates may perhaps be delayed to one or two weeks later with safety. The earlier the season, the sooner the pruning should be done.

TRAINING SYSTEMS

There are three systems of training fruit trees:

1. Leader or pyramid type of tree.
2. Delayed open-center or modified-leader type of tree.
3. Open-center or vase-shaped type of tree.

Leader Type.—This system was at one time in quite common use in America, and is still to be found in some of the older orchard sections of the east, as well as in European countries. In training a tree by this system, the topmost branch is encouraged to gain the ascendency (fig. 11), and as time passes the tree becomes pyramid-shaped, although, on account of the shading of upper branches, it is

Fig. 12.—A Bartlett pear started as a "modified-leader" type of tree. Note that the upper shoot has been pruned somewhat longer than the others in order to encourage greater growth from this limb. See figs. 13 and 14.

difficult at times to maintain the lower limbs. This type of tree, however, has nothing to recommend it to the commercial orchardists of California, and is simply mentioned for the sake of completeness.

Delayed Open-Center Type.*—Trees of this type are occasionally seen in California, although not to the extent the system merits. At the time of the first heading-back, the topmost limb is left considerably longer than the other scaffold branches (fig. 12). Such a proceeding results in the strong growth of this limb (see page 122). At subsequent prunings, growth from this topmost branch must be subdued by heavy cutting and the remainder of the tree allowed to thrive (fig. 14). The reason for uneven cutting at first, followed by a repression of the favored part, is to enable the grower to obtain a

* The author is indebted to E. J. Kraus for this term.

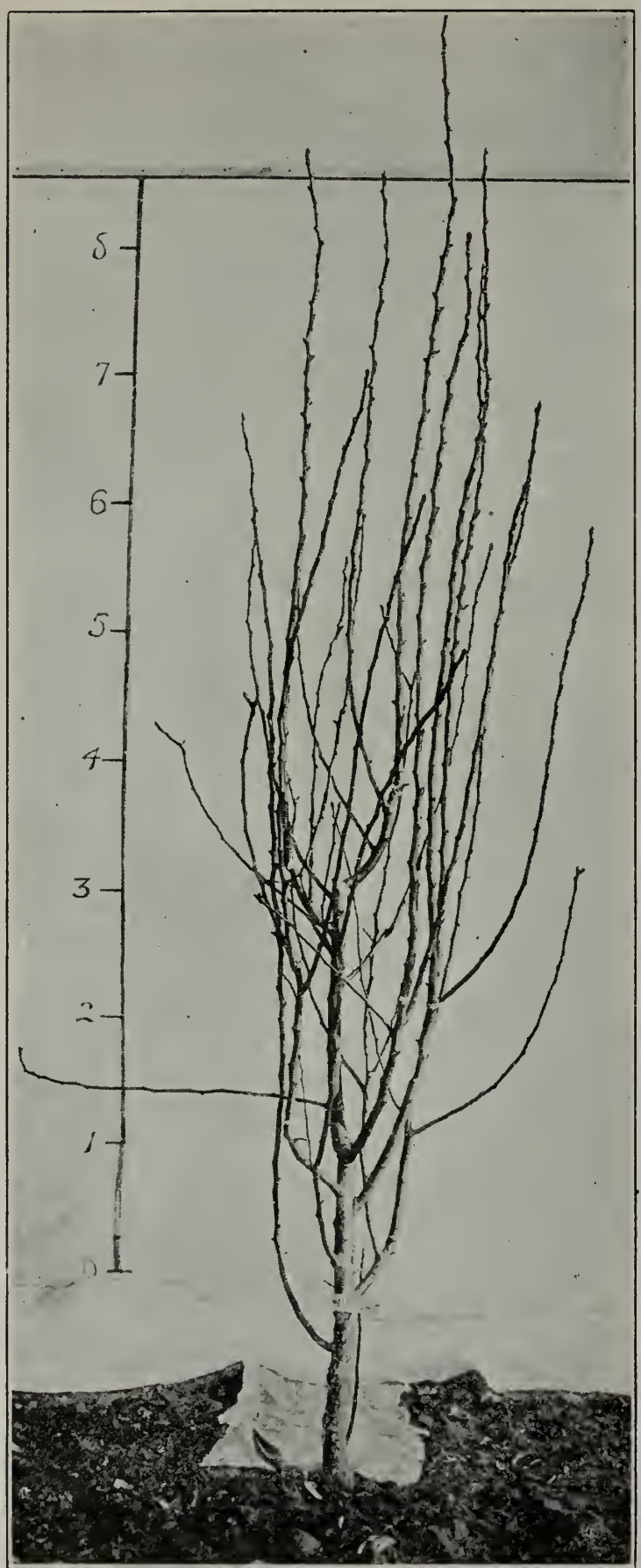

Fig. 13.—The same Bartlett pear as in fig. 12 after the second season's growth in the orchard. Note the vigorous wood growth of the entire tree. Particular attention is drawn to the greater girth of the uppermost scaffold which was cut longer than the others at the first dormant pruning, again emphasizing the fact that greater stockiness results from lighter cutting. See fig. 14.

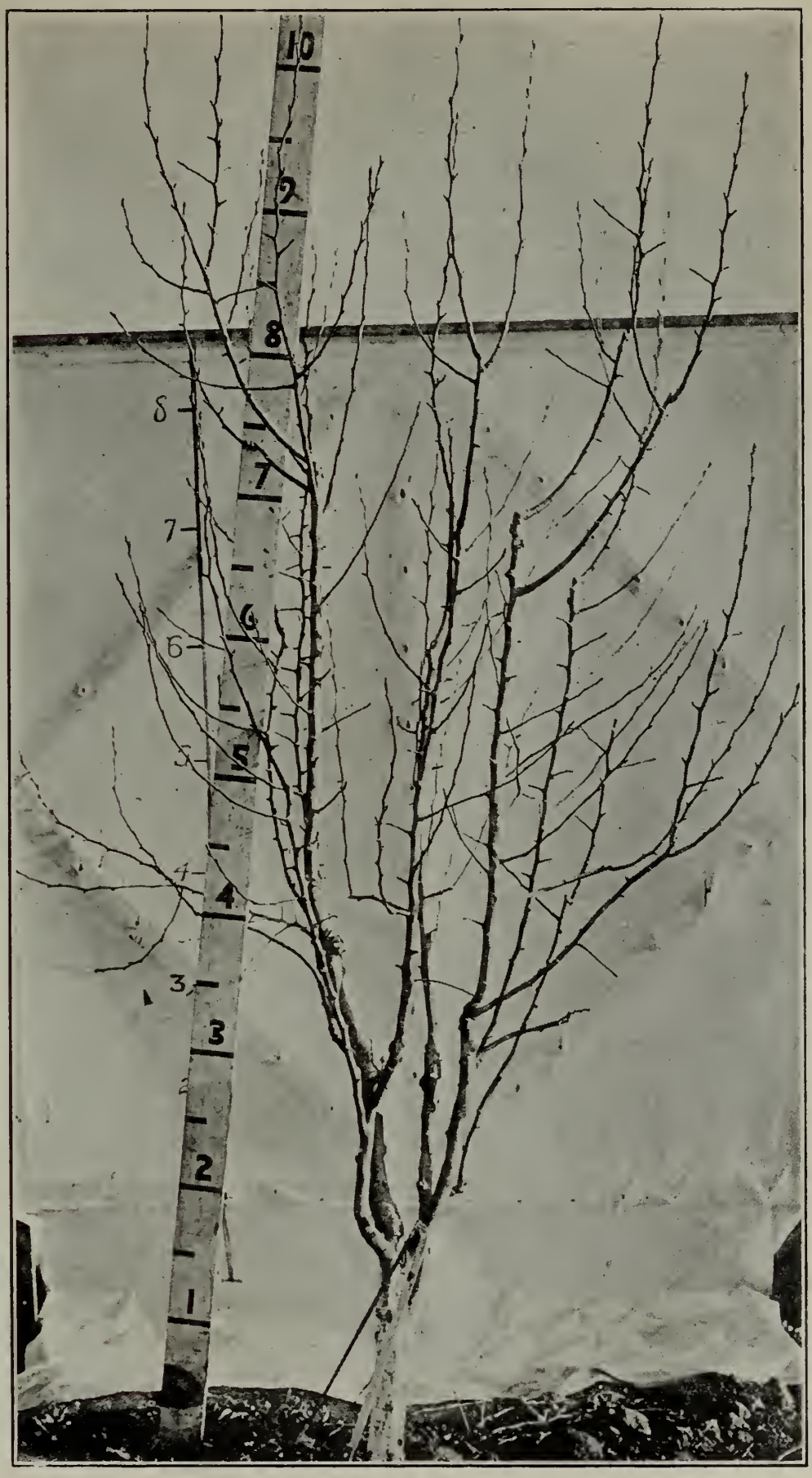

Fig. 14.—The same Bartlett pear tree as in figs. 12 and 13 after four seasons' growth in the orchard. Photograph taken after pruning. Note strong, sturdy framework and symmetry of the tree. Lower branches have been permitted to overtake upper branches so that tree is now nicely balanced.

greater spacing of the scaffold branches on the trunk, the importance of which has already been discussed. Many varieties of the apple, cherry, pear, and European plum (including the prune) adapt themselves particularly well to this style of training. The term "delayed open-center" is used advisedly because by the system just outlined the tree is opened out just as is the case with the true open-centered tree, with the difference that in the latter type of pruning the open center is obtained immediately at the time of the first heading-back, but in the former case two to three or four years may be necessary. Nevertheless, trees pruned by the two methods may be expected to come into bearing at about the same time, but with the delayed open-center tree somewhat stronger and better shaped than the strictly vase-shaped tree.

Open-Center Type.—Probably 75 per cent or more of the deciduous fruit trees in California are of this general type. It has proved entirely satisfactory when properly applied. The one glaring defect of this system has been the encouragement of all scaffold branches to arise from one point on the trunk, with the formation of basin crotches or "water pockets" (fig. 15), especially in upright-growing varieties such as the French prune. Consequent heart-rot occurs, with breakage from a heavy load of fruit when the trees should be producing maximum crops. With this system, branches arising from the main trunk are given equal encouragement from the first. The centers are kept as open as is compatible with freedom from sunburn of the branches. The degree of openness of the center varies with the species, local conditions, and the personal ideal of the grower.

HEIGHT OF HEAD

One of the factors limiting the profitable establishment of the orchard under California conditions is the height of the head. The lower the head, the greater will be the shading of the trunk and consequently the less sunburn or sunscald resulting. This point should be especially emphasized for orchards planted in the hot interior valleys.

Whitten[11] reports that records taken during the hottest days in Missouri showed the temperature of short trunks to be several degrees lower than that of long trunks, even when the limbs of the former were spread upward to expose the thermometers equally to the sun's rays. Tall trunks exhibited more sunscald than did short trunks even where the latter were not shaded.

The lower temperature (and less scald) may be explained on the hypothesis that short trunks were cooled by readier and more abundant passage of sap from roots to closely adjacent limbs. Plants that bleed (e.g., maple and grape), bleed less and less the higher up they are cut, and more and more the nearer to the roots the cut is made.[7]

In the same experiments conducted in Missouri it was found that where trunks were covered with growing spurs and rosettes of leaves the temperature was lower than on naked trunks which had no leaves

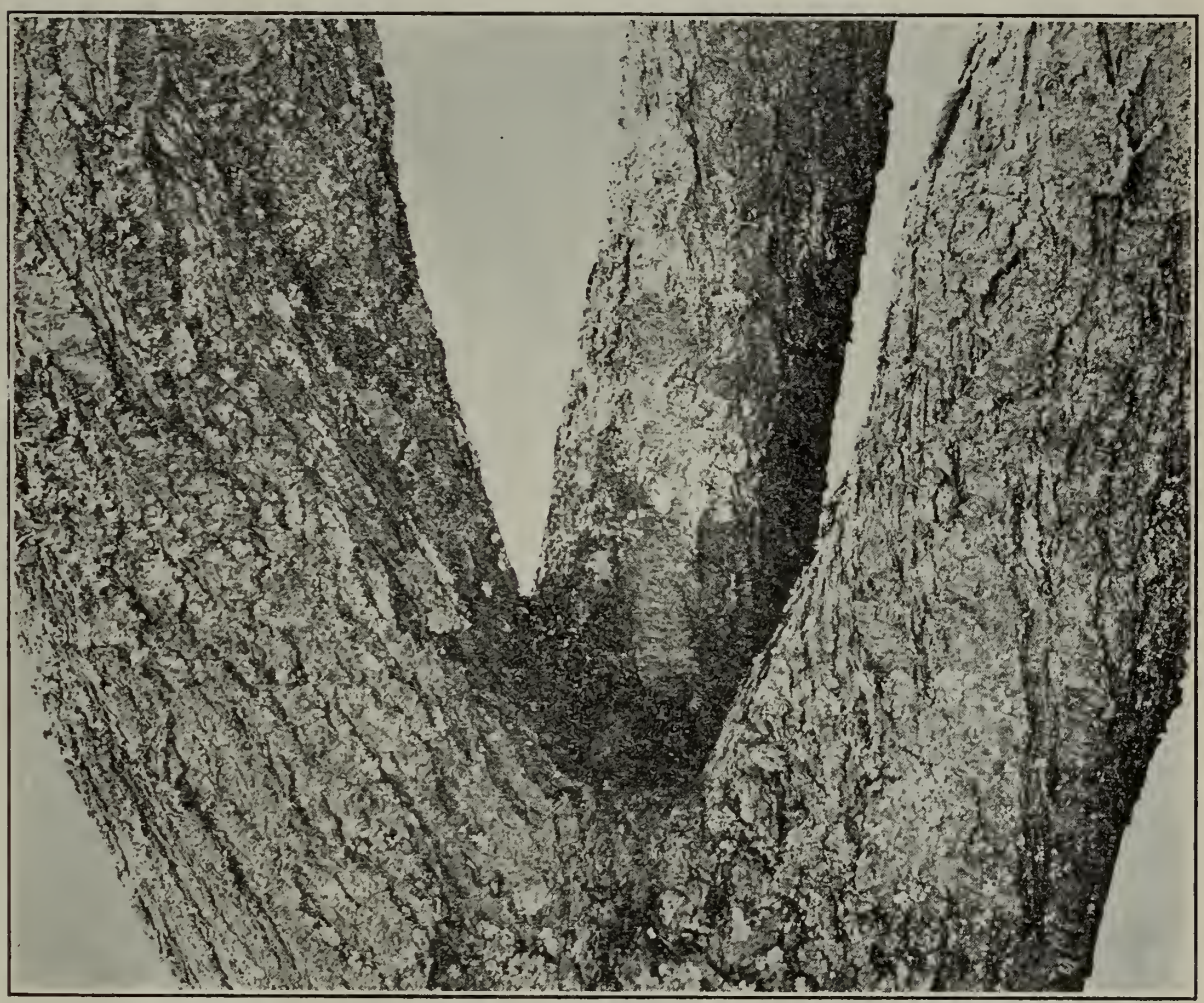

Fig. 15.—The result of selecting branches arising from one point on the main trunk. In this so-called water pocket note that the entire blade of the knife is under water. This photograph is of a ten-year-old almond tree. The trouble is only just beginning, and unless immediate steps are taken for its remedy the usefulness of the tree will be shortened many years.

low down to evaporate water and thus cool adjacent parts. The above facts hold true even when the two trees (one with short and the other with long trunk) had similar branch growth higher up.

The removal of leaves (checking evaporation near the inserted thermometer) caused a rapid rise of trunk temperature to 8 degrees

Fahr., nearer the atmospheric temperature.* This shows that evaporation of water through the leaves on higher twigs does not cool the trunk so much as evaporation from leaves on trunk or main limbs.

Whitten[11] also states that low-headed as compared with high-headed trees show a more vigorous condition, as witnessed by greater trunk and root development. The question is raised but not answered as to whether the distance between top and root may not have a distinct bearing on the nutrition of these parts.

A low head does not necessarily mean that cultivation close to the trees will be impossible. Branches may arise from near the ground and yet grow at such an angle that close cultivation is practicable. With modern extension tools of culture it is not so necessary to keep the spread of the trees above the horses' heads, and every effort should be made to keep both the height of the head and the spread of branches as low as is consistent with good culture. The lower the tree the cheaper will be the costs of orchard management. The expenses of pruning, spraying, thinning, and harvesting vary directly with the height of the fruiting area above the ground.

Other advantages of a low head are, less breakage from winds, fewer windfalls, and, as opposed to extremely high heads, where an extra season is sometimes taken to grow additional trunk, low-headed trees may come into bearing sooner.

The fact should again be emphasized that pruning is only one of the factors limiting profitable orchard productivity. Careful pruning treatment cannot be expected to atone for deficiencies of soil fertility, moisture, or for an unfavorable climate, or otherwise to take the place of careful and intelligent orchard management.

PRACTICAL SUGGESTIONS ON THE SHAPING OF YOUNG FRUIT TREES

Experiments with the training of fruit trees, performed under California conditions, have not proceeded far enough to enable the writer to state definitely the way a young orchard should, under all circumstances, be pruned. The recommendations herewith presented are not to be taken as final,† but are based on the best information at present available.

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* In one instance the air temperature was 103° F. The trunk temperature was 90° F., so long as adjacent rosette of leaves was intact. The trunk temperature rapidly rose to 98° F. upon removal of the leaves, with the air temperature remaining constant at 103° F.

† It is planned, as our experiments progress, to issue publications from time to time dealing with the pruning of particular fruits.

For the purpose of this discussion the different deciduous* fruits may be roughly grouped into two classes according to habit of growth. The first class contains those fruit trees which form side branches on current season's growth; this includes the almond, apricot, peach, and Japanese plum. The trees of the second class or group, the apple, cherry, pear, European plum and prune, do not form side branches on the current year's wood. The above grouping does not necessarily mean that all trees in the same class should receive the same pruning treatment.

As a general statement it may be said that the trees of the first class can be brought into bearing somewhat sooner than those of the second class. Likewise, the formation of a symmetrical framework is more quickly attained with trees in the first class than with those in the second.

Pruning Young Almonds, Apricots, Peaches, and Japanese Plums.

1. The nursery tree should be cut at planting at a height of twenty to twenty-four inches above the ground (p. 119). With the fruits of this class the head of many of the trees may be formed immediately at planting time by making use of side branches formed in the nursery. In case these branches are unsuitable, they should be removed. In this operation care should be taken not to injure the ring of tissue which surrounds the twig at its juncture with the trunk. It is from this tissue that the so-called "blind-eyes" (adventitious buds) give rise to new shoots.

2. The young trees should receive a coat of whitewash soon after planting, to prevent sunburn on the trunk (p. 138).

3. During April the orchard should be carefully pruned and all undesirable growths pinched back (p. 128).

4. At the first dormant pruning the trees should be thinned to three main branches, properly spaced (p. 119), and these limbs cut back lightly above the secondary branching. In other words, the trees in this group should not be cut to "stubs" except when absolutely essential. Figure 16 shows a branch of an apricot tree cut to a stub at the previous pruning, and figure 17 shows the same branch after the undesirable branches have been removed. Attention is called to the pruning wounds caused by cutting to "stubs" and the poor crotch resulting. This condition is largely obviated by cutting to laterals as in figure 18*b*.

* No pruning experiments have as yet been conducted with the fig, pecan, persimmon, and walnut. These fruits belong in general to the second group as above described.

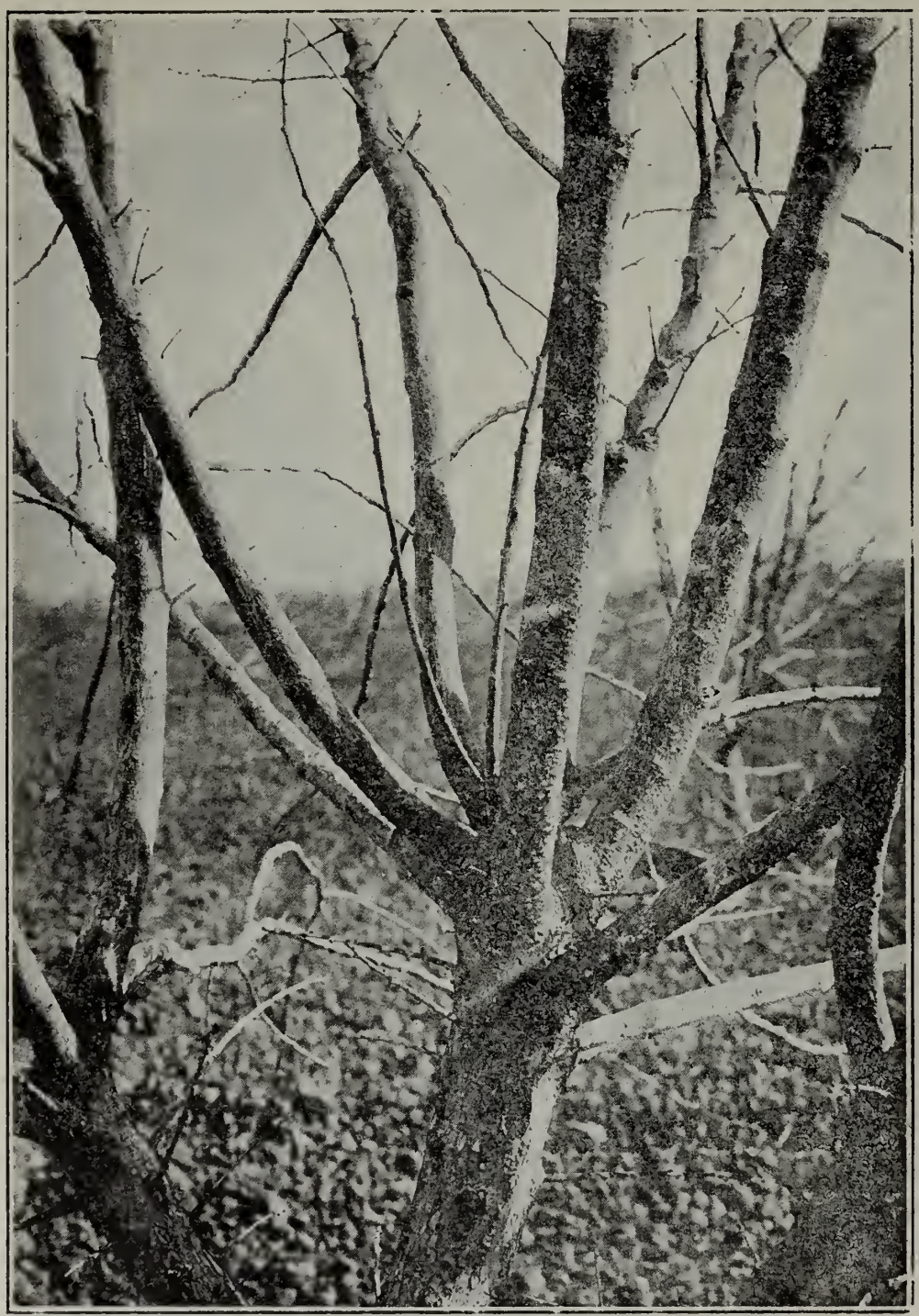

Fig. 16.—A branch of an apricot tree cut severely to a stub at the preceding dormant pruning. Compare fig. 17, which shows the same branch after pruning. Unnecessary wood growth should have been removed early in May and little pruning would have been necessary through the winter. Better still, this branch should not have been cut back so heavily at the previous pruning.

5. During May of the second summer the trees are in the orchard, all unnecessary growth should be "thinned-out." If the trees are making a vigorous growth and the desired spread and number of branches are not sufficient for the ultimate framework, then in addition to the thinning, a "heading-back" may be given (p. 128).

6. At the second dormant pruning the tree will need only a thinning-out (p. 121).

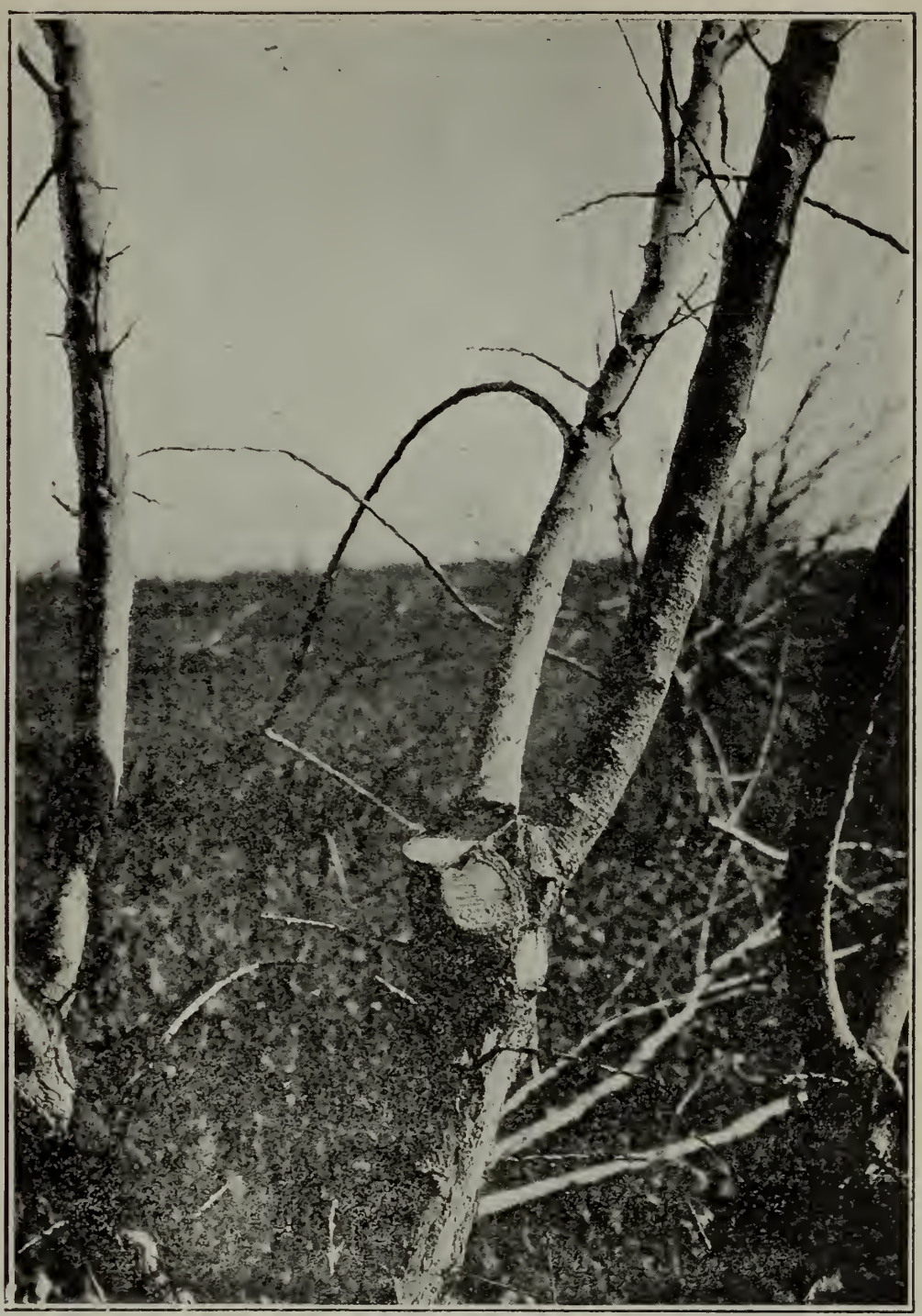

Fig. 17.—The same apricot branch as in fig. 16 after having been pruned. Note the weak crotch and large pruning wounds. Such severe pruning would not have been necessary if tree had been cut lighter during preceding winter or else unnecessary growth removed early in the growing season.

7. The same treatment should be given at the third as was given at the second dormant pruning.

8. Trees in this first group handled as above outlined should produce a good commercial crop during the fourth season in the orchard, and may thereafter be handled as full-bearing trees.

9. All of the above discussion presupposes good soil conditions and careful cultural treatment.

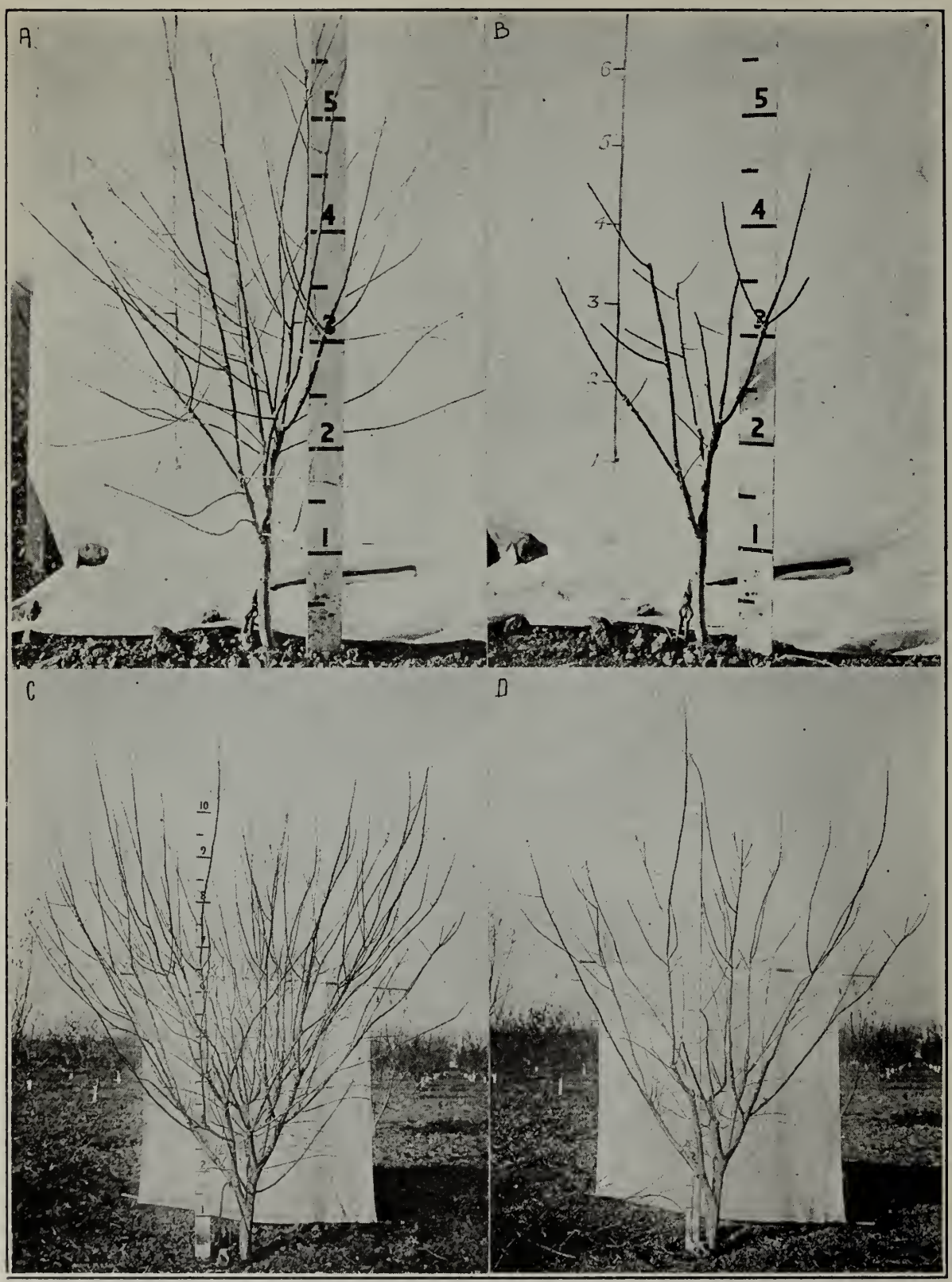

Fig. 18.—*a*, Nonpareil almond after one season's growth in the orchard. Head was formed from nursery branches at time of planting. Note good, strong, vigorous growth. *b*, Same tree as in (*a*) after pruning. Note that the tree was thinned-out and headed lightly to laterals. *c*, Same Nonpareil tree after two seasons' growth in the orchard. This tree was thinned and headed lightly in May of the second summer. Note the large number of fruit-spurs formed on both one- and two-year-old wood. *d*, Same tree as in (*c*) after pruning. Note that all the main branches are formed and that no further heading-back is necessary. This tree should produce a good crop during its fourth season in the orchard.

Fig. 19.—*a,* Apricot tree cut to a 24-inch whip at planting. *b,* Apricot tree with head formed at planting time from laterals formed in the nursery row. *c,* Apricot tree one year old cut back moderately to laterals. *d,* Royal apricot tree two years old after pruning—thinned-out only—not headed-back. *e,* Same tree as in (*d*) after one year's growth. Note strong, sturdy framework and vigorous new growth. *f,* Same tree as in (*d*) and (*e*) after pruning by thinning-out only. This tree produced good crops during both third and fourth summers it was in the orchard.

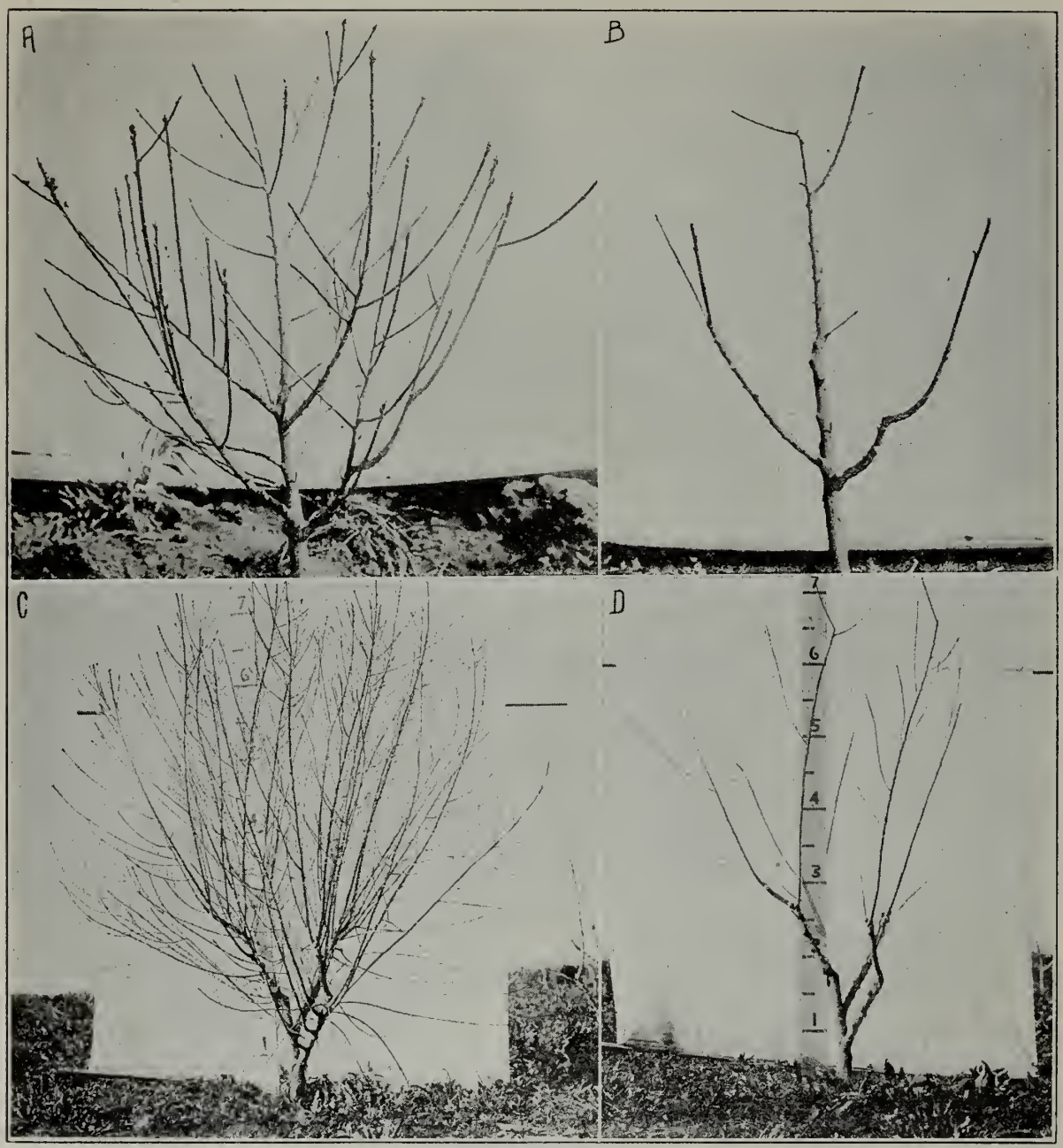

Fig. 20.—*a,* Peach tree after one season's growth in the orchard—cut to a whip at planting. *b,* Same tree as in (*a*) after pruning. Note heavy thinning-out but rather light heading-back. Heading-back was necessary to secure upright branches near pruning cuts. *c,* Peach tree after two seasons' growth in the orchard. Note vigorous shoot growth. *d,* Same tree as in (*c*) after pruning. Note heavy thinning-out but *no* heading. Only those laterals left which might form desirable permanent branches.

Pruning Young Apples, Cherries, Pears, European Plums and Prunes.

1. The nursery tree should be cut at planting at a height of twenty to twenty-four inches above the ground (p. 119).

2. The young trees should receive a coat of whitewash soon after planting to prevent sunburn on the trunk (p. 138).

3. During April the orchard should be carefully pruned, the three main scaffold branches being selected and all undesirable growths being pinched back (p. 128).

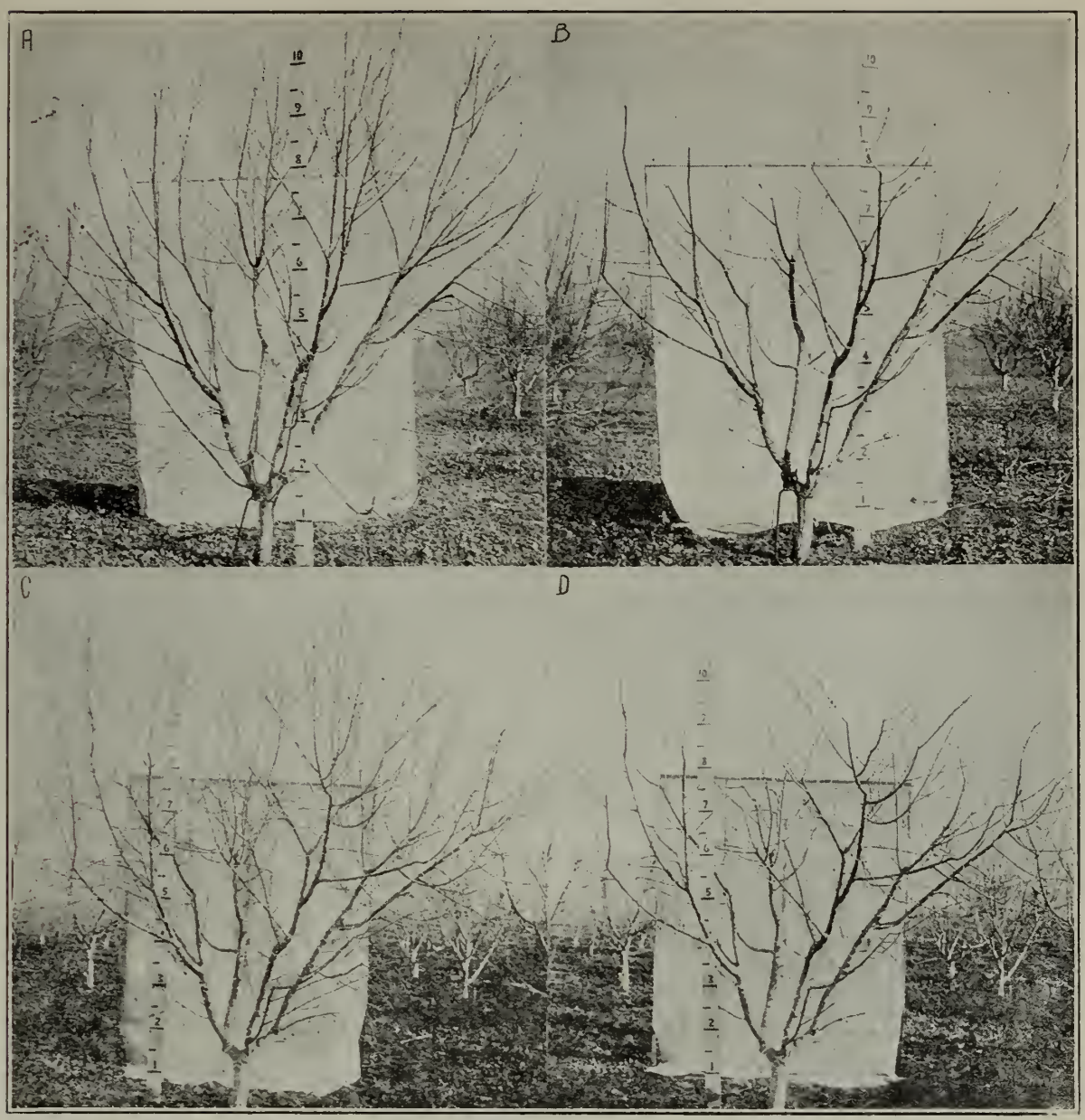

Fig. 21.—*a*, Three-year-old peach tree before pruning—pruned as outlined in fig. 20. Note sturdy framework and abundance of new wood growth. *b*, Same tree as in (*a*) after pruning—thinned-out heavily. *c*, Four-year-old peach tree before pruning—same tree as in (*a*) and (*b*). This tree produced over 100 pounds of first quality fruit during its fourth season in the orchard. Note vigorous wood growth. *d*, Same tree as in (*a*), (*b*), and (*c*) after pruning. Heavily thinned-out. Note sturdy framework capable of holding up heavy crops.

4. At the first dormant pruning the trees should be thinned to the three main branches, properly placed (p. 119), and these limbs cut back so that they will be from fifteen to thirty inches or more long (p. 120).

5. During May of the second summer the trees are in the orchard, all unnecessary growth should be "thinned-out." If the trees are making a vigorous growth, a "heading-back" of the secondary scaffold branches, in addition to the thinning process may be given. Under favorable conditions, this practice will result in the securing of the

usual second and third year's shaping during the second season (p. 131).

6. With the exception of all varieties of the sweet cherry and of certain varieties of the other fruits of this group, the pruning given during the second dormant season will consist of a "thinning-out" only.

"Heading-back" one-year branches, under most conditions and in many varieties of apples, pears, European plums and prunes, will have a decided tendency towards forcing all new shoot growth to arise from near the pruning cuts. On the other hand, if these same branches are not cut back, the new shoots, except in certain varieties, will be well distributed up and down the previous year's growth. Notable exceptions to this rule are the Spitzenburg apple, Lincoln pear, and the Pond plum, which follow the habit of the sweet cherry, in that new shoot growth arises from the tip of one-year wood whether this has or has not been headed.

7. The same pruning as that outlined for the end of the second growing season should be given during the third dormant season and until the trees come into bearing.

Prunes and European plums may be expected to come into profitable bearing somewhat sooner than apples and pears. The latter fruits in general bear sooner than cherries. The question of variety plays a most important role in determining the age at which a certain fruit may be expected to reach profitable bearing. For example, the Wagener apple is noted for its precocious fruiting, while the Northern Spy is notoriously slow in reaching productivity.

8. Trees in this second group, as above designated, may be expected to reach profitable bearing during the fourth to eighth season, and should thereafter be handled as full-bearing trees.

9. All the above discussion presupposes good soil conditions and careful cultural treatment.

SUMMARY

1. Young trees should have their tops cut back at planting in order to

a. Balance the loss of roots removed in digging from the nursery.

b. Form a low head for future profitable orchard management.

2. Sunburn in part may be controlled through shading, by means of low-headed trees, and by the cooling effects of evaporation from adjoining leaves. Long bare trunks have higher temperature than short trunks.

3. Three main "scaffold" limbs are all that are desirable, and these should be spaced six to eight inches apart at the points where they arise from the trunk.

4. Nursery lateral branches, if properly distributed, may be utilized in forming the head of the tree at planting time.

5. Six main branches at five feet from the ground are sufficient for a mature tree.

6. After securing the desired number of main branches, together with the proper spread, it is useless, except with certain kinds and varieties, to head back the young tree again.

7. Lightly pruned trees have stockier and stronger branches than heavily pruned trees.

8. The more lightly a tree is pruned, the greater is its development.

9. The storage of plant food per unit of shoot growth is greatest near the tip.

10. To lessen total growth in any branch or part of a tree, cut that branch or part heavily. To increase the total growth in any part, prune that part lightly.

11. Lightly pruned trees come into bearing from one to three years earlier than similar trees that have been heavily pruned.

12. Early bearing is not inimical to future productivity.

13. Summer pruning is weakening and results in somewhat smaller trees. Under certain conditions, however, this practice may be advisable and may hasten profitable production.

14. Early summer growth of the tree (to approximately June 15) is made at the expense of plant food stored the preceding summer.

15. After June 15 the tree is mainly occupied in the manufacture and storage of plant food for the succeeding year's wood growth and fruit production.

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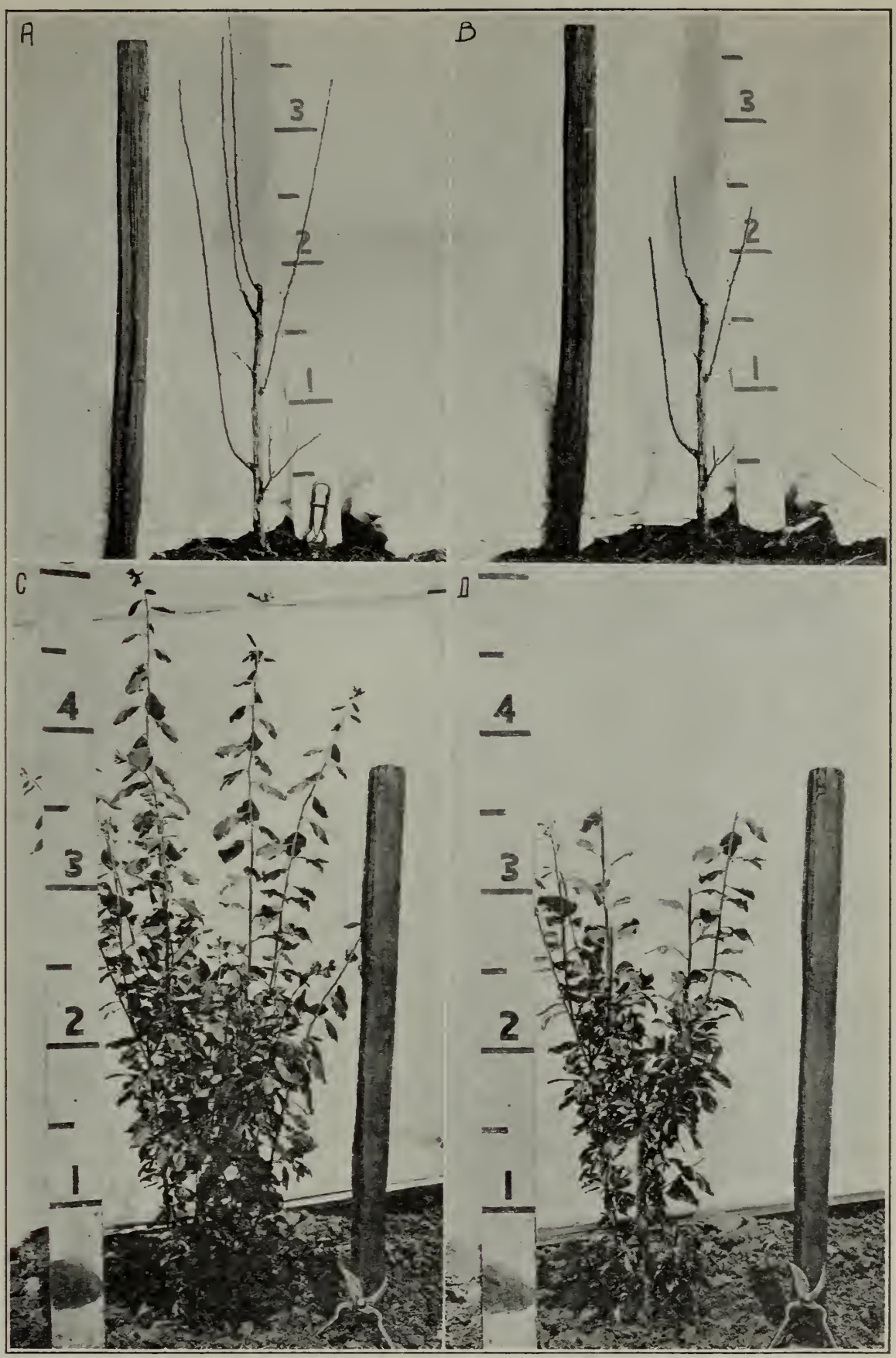

Fig. 22.—*a*, One-year-old prune tree. Note splendid distribution of branches, secured by pinching undesirable growths in April after planting. *b*, The same tree as in (*a*) after pruning. Thinned to three scaffold branches and these headed-back lightly. Note spur left near ground for shade. *c*, Prune tree during May of second summer. Same tree as in (*a*) and (*b*). Note vigorous new shoot growth. *d*, Same tree as in (*c*) after having received a summer-pruning consisting of a light thinning and heading.

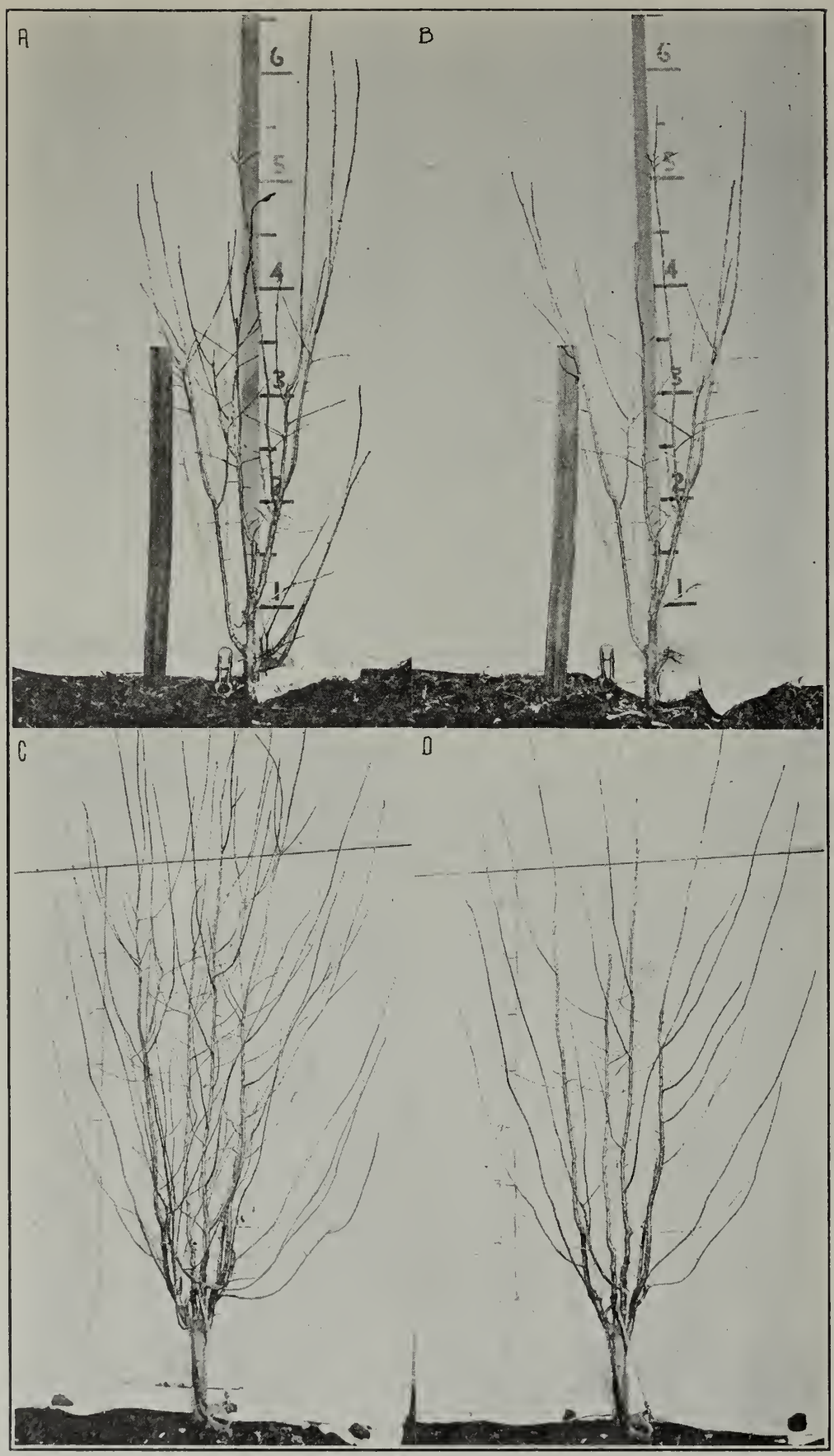

Fig. 23.—*a*, Two-year-old French prune tree. Same tree as in fig. 22. Note laterals forced by the summer-pruning; also fruit-spurs on both one -and two-year-old wood. *b*, Same tree as in (*a*) after pruning by thinning-out. Note that framework is complete. No need for further heading. *c*, Three-year-old French prune tree before pruning. Thinned only at second dormant pruning. Note abundance of new wood growth and numerous fruit-spurs. d, Same tree as in (*c*) after pruning by thinning. This tree produced fifteen pounds of green fruit the fourth season. Note poor main crotch in this tree caused by scaffolds arising from one point.

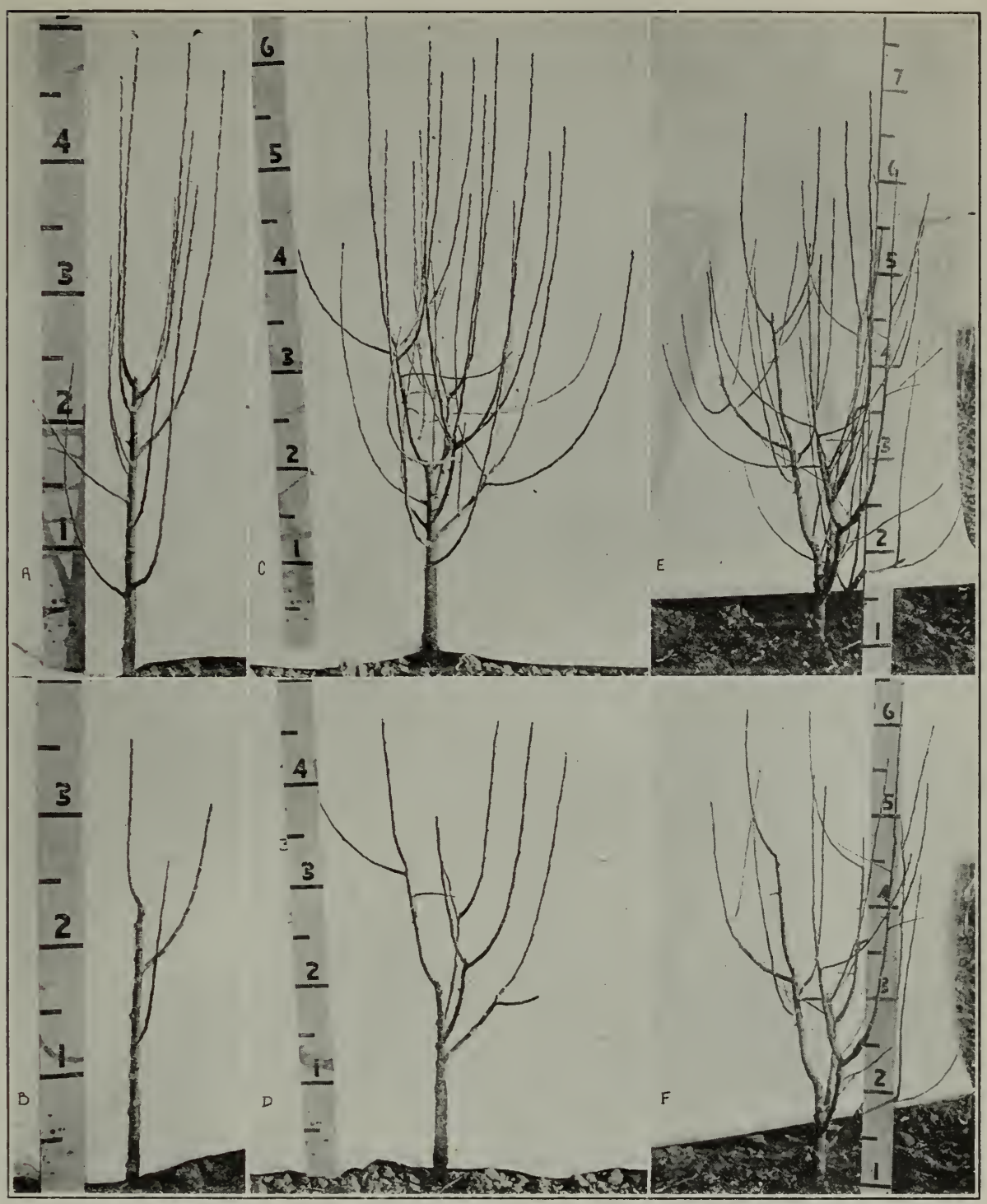

Fig. 24.—*a,* One-year-old apple before pruning—a good vigorous growth. *b,* One-year-old apple after pruning. Note splendid distribution of main branches. *c,* Two-year-old apple before pruning. *d,* Two-year-old apple after pruning. Thinned-out and lightly headed—in some cases it might have been advisable not to head at this time. This is largely a matter of varietal characteristics. *e,* Three-year-old apple before pruning—note good, vigorous growth. *f,* Three-year-old apple after pruning—thinned-out only. A good strong framework is already formed.